# Validation and climate projections of the ALARO-0 model on the EURO-CORDEX domain

O. Giot[1,2], P. Termonia[1,3], D. Degrauwe[1], R. De Troch[1,3], S. Caluwaerts[3], G. Smet[1], J. Berckmans[1,2], A. Deckmyn[1], L. De Cruz[1], P. De Meutter[1,3], F. Duchêne[1], A. Duerinckx[1,3], L. Gerard[1], R. Hamdi[1], J. Van den Bergh[1], M. Van Ginderachter[1,3], B. Van Schaeybroeck[1],

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1. ALARO-0 climate runs at RMIB: status
2. Validation of ALARO-0 for climate
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# A little bit of history

Extended downscaling experiment by De Troch *et al.*, JoC, 2013:

- Evaluation of ALADIN and ALARO-0 cy36t1 at 40, 10 and 4 km.
- Initial and lateral boundary conditions: ERA-40 or model at 40km resolution (one-way nesting)
- 40-year run with daily reinitializations
- Reference: to station observations 1961-1990

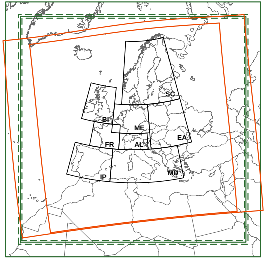
Thanks to the 3MT physics parameterization scheme, ALARO-0 generates **consistent results across scales** and correctly represents **extreme daily precipitation**, even at high resolutions.

Results indicate that ALARO-0 is a good candidate for regional climate modelling.

# ALARO-0 climate runs at RMIB

Participation in the **Coordinated Regional Climate Downscaling Experiment (CORDEX)**:

- Runs are performed with **ALARO-0 cy36t1**
- Boundary conditions: ERA-Interim (evaluation)
  or CMIP5 GCM: CNRM-CM5 (historical and future)
- Run continuously (one month at a time) for a 31-year period.
- Domain and resolutions: EUR-44 ($0.44^\circ \approx 50$ km) and EUR-11 ($0.11^\circ \approx$ **12.5 km**)



# Validation

Validated using state-of-the-art performance metrics.

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www.geosci-model-dev.net/9/1143/2016/
doi:10.5194/gmd-9-1143-2016


Geoscientific Model Development
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## Validation of the ALARO-0 model within the EURO-CORDEX framework

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# Current status

Runs are ongoing on the Tier-1 supercomputer at Ghent University. The checked runs are finished or ongoing, green ones are next.

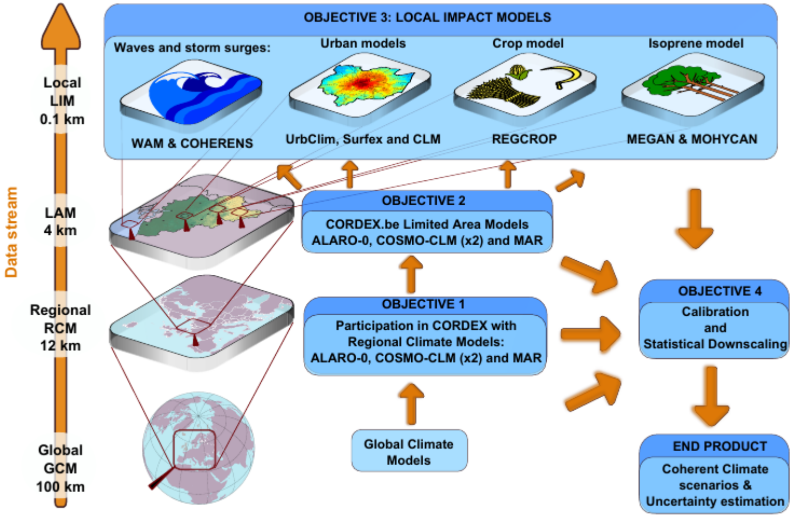
| | Analysis | Historical | RCP 2.6 | RCP 4.5 | RCP8.5 |
|---|---|---|---|---|---|
| 1976-2005 | ✓ | ✓ | - | - | - |
| 2005-2040 | - | - | × | × | × |
| 2040-2070 | - | - | ✓ | ✓ | ✓ |
| 2070-2100 | - | - | ✓ | ✓ | ✓ |

# National project

CORDEX.be

- Dynamical downscaling of EURO-CORDEX 12.5km or 50km runs on a high-resolution $\mathcal{O}$(4km) domain over Belgium
- In addition to our contribution with ALARO-0, partner institutes use e.g. COSMO-CLM, MAR
- This provides an ensemble of high-resolution climate runs for local impact modellers.

# National project: CORDEX.be



# Technical challenges

- Creating netCDF files that conform to the CORDEX **archive specifications**
- Processing 100s of TBs of historical files to extract TBs of data
- ... in R: new R package CordextractR (flexibility required!)

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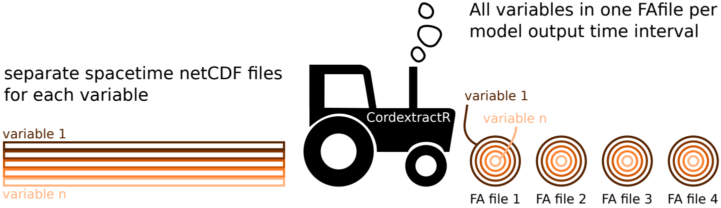

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  - Specify your in/output variables of choice, including functions such as sum, modulus, mask, threshold, max... in a **declarative** way
  - Set-up of a data conversion pipeline using producer-filter-consumer pattern (avoids (computation-intensive) logic/branches during the conversion)
  - **Fast** conversion (in spite of R): the bottleneck is mainly IO
  - **Unit tests** for all functions

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  - **Unit tests** for all functions
- Submitting data to the ESGF nodes (many of which have been down for a while...)

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# Validation of ALARO-0 for climate

Evaluation run:

- Lateral boundary conditions from the ERA-Interim reanalysis
- Continuous 31-year run (1979-2010)
- Reference: E-OBS 7 data set

Can ALARO-0 represent the most important features of the European climate?

In practice:

1. Is ALARO-0 competitive with other EURO-CORDEX ensemble members, using the **standardized performance metrics** as in Kotlarski *et al.*, 2014?
2. Are these metrics **robust**?

# Performance metrics

Scores are based on seasonal mean values of near-surface air temperature and precipitation.

- BIAS: mean bias
- 95%-P: 95th percentile of the absolute grid point differences
- RSV: ratio of spatial variability
- PACO: pattern correlation
- RIAV: ratio of interannual variability
- TCOIAV: temporal correlation of interannual variability

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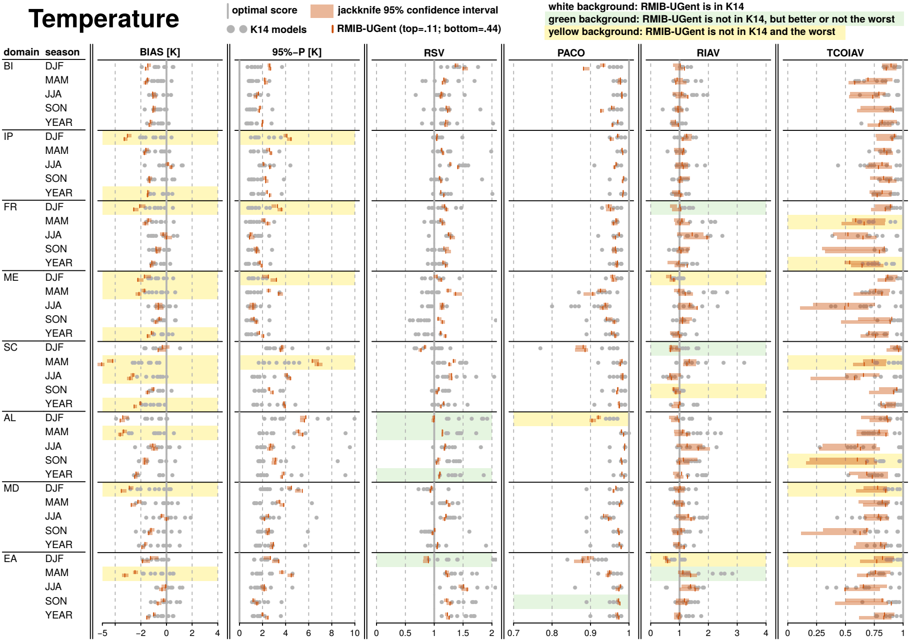
# Robustness

Are the scores **robust**, i.e. independent of the period used?
$\Rightarrow$ Jackknife procedure:

- Calculate all scores for 1000 random 20-year samples out of the 32-year period
- Construct 95% confidence intervals
- Compare interval width to the ensemble spread.



Temperature
optimal score
K14 models
jackknife 95% confidence interval
RMIB-UGent (top=.11; bottom=.44)
white background: RMIB-UGent is in K14
green background: RMIB-UGent is not in K14, but better or not the worst
yellow background: RMIB-UGent is not in K14 and the worst
domain season
BIAS [K]
95%–P [K]
RSV
PACO
RIAV
TCOIAV
BI
IP
FR
ME
SC
AL
MD
EA
DJF
MAM
JJA
SON
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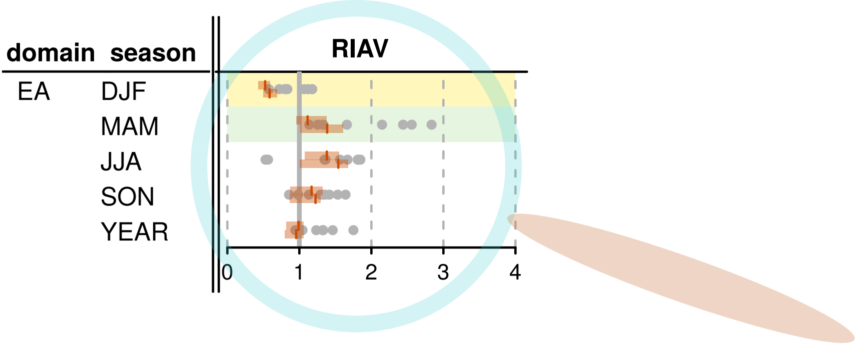


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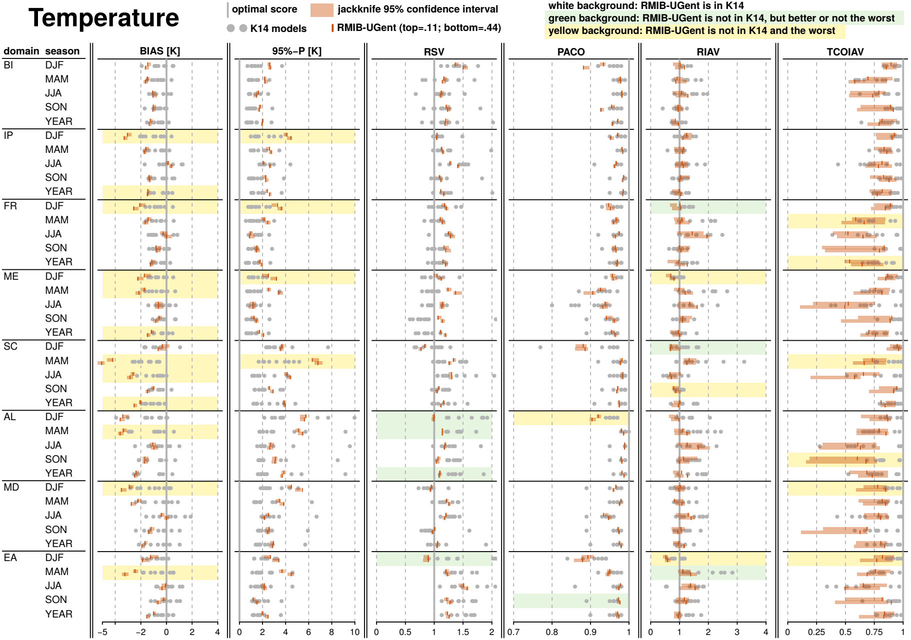
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BI DJF MAM JJA SON YEAR
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ME DJF MAM JJA SON YEAR
SC DJF MAM JJA SON YEAR
AL DJF MAM JJA SON YEAR
MD DJF MAM JJA SON YEAR
EA DJF MAM JJA SON YEAR
−5 −2 0 2 4
0 2 4 6 8 10
0 0.5 1 1.5 2
0.7 0.8 0.9 1
0 1 2 3 4
0 0.25 0.5 0.75 1

# Precipitation

optimal score | jackknife 95% confidence interval
K14 models | RMIB-UGent (top=.11; bottom=.44)

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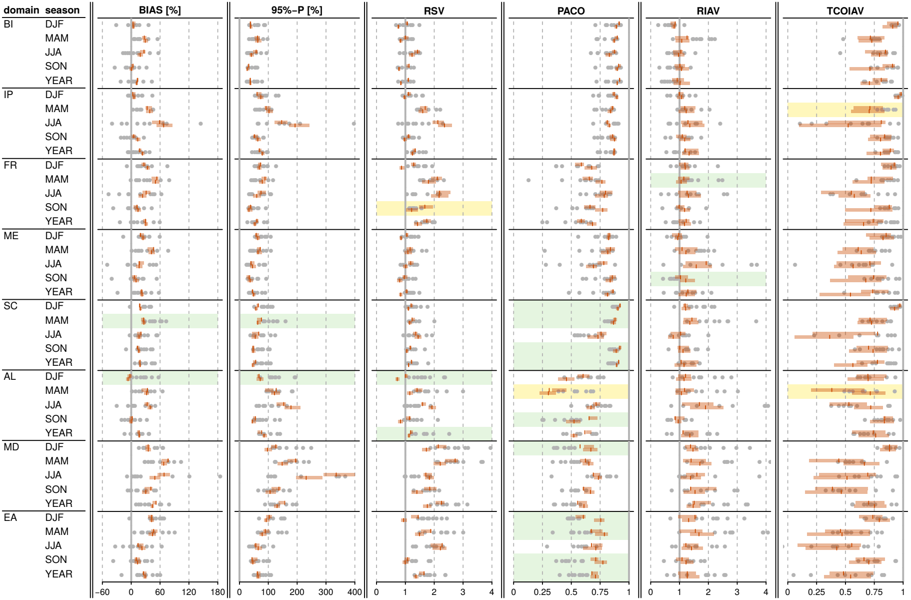
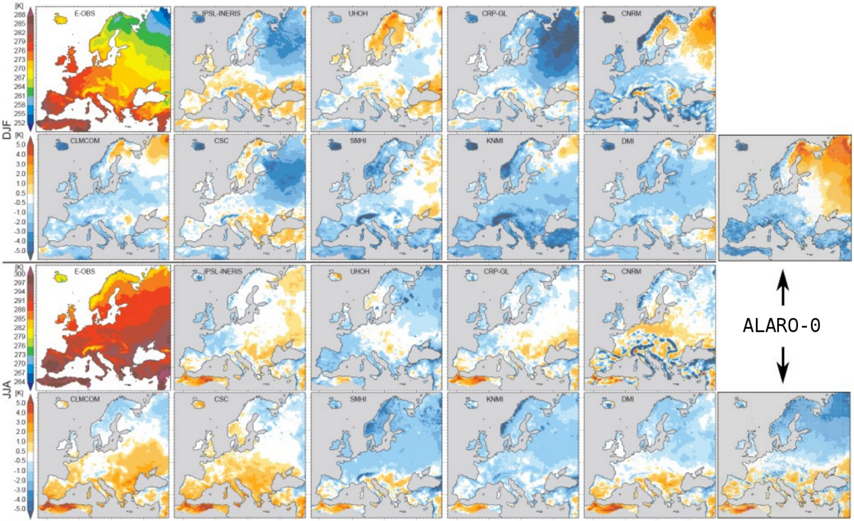
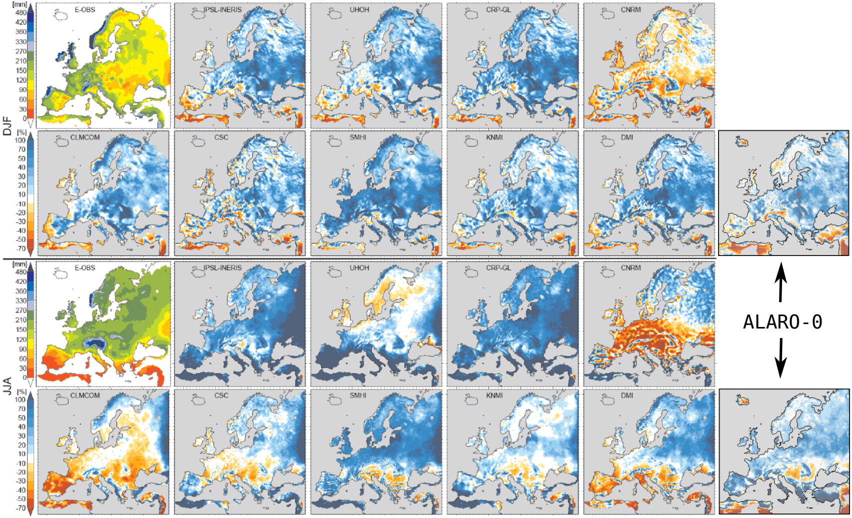


# Temperature bias patterns



# Precipitation bias patterns



# Conclusions

A state-of-the-art validation was performed of the ALARO-0 evaluation run of RMIB-UGent, following standardized metrics.

- ALARO-0 performs well, despite not being tuned for climate: cfr. white/green backgrounds
- Temperature biases persist in Scandinavia / Eastern Europe (same spatial pattern as ARPEGE)
- For precipitation, ALARO-0 often outperforms all other models!

Robustness test: all scores except RIAV and TCOIAV are robust

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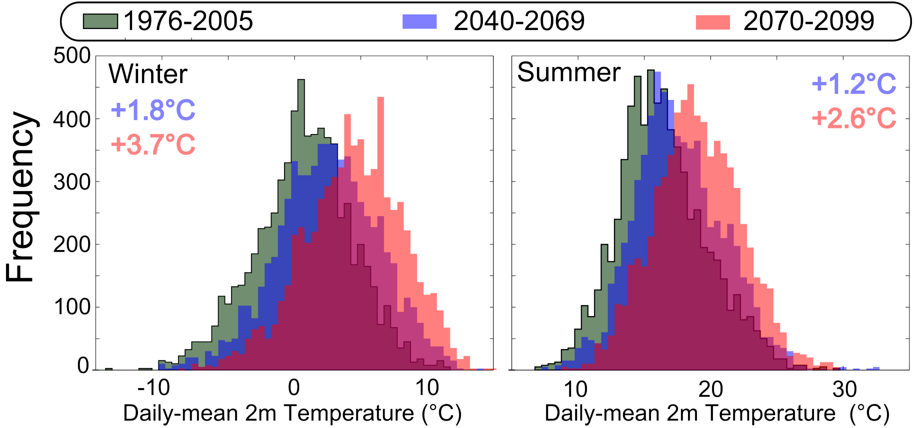
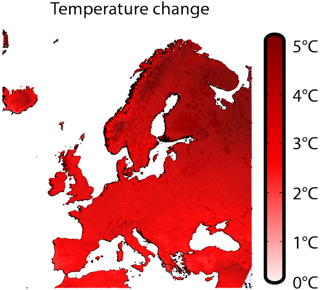
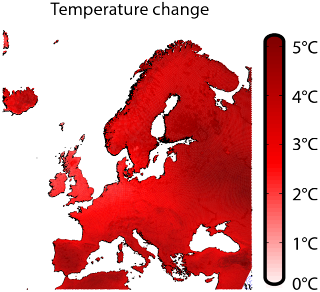
# RCP 8.5 vs historical T2m (Uccle, Belgium)



# Change in temperature: RCP 8.5 (2070-2100) vs historical (1976-2005)

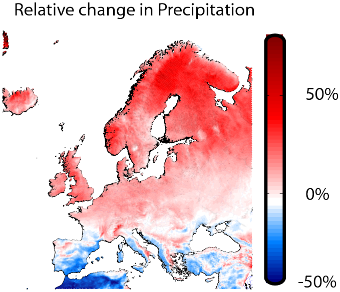



Winter

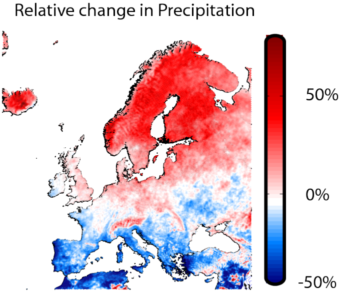



Summer

# Change in precipitation: RCP 8.5 (2070-2100) vs historical (1976-2005)




Winter




Summer

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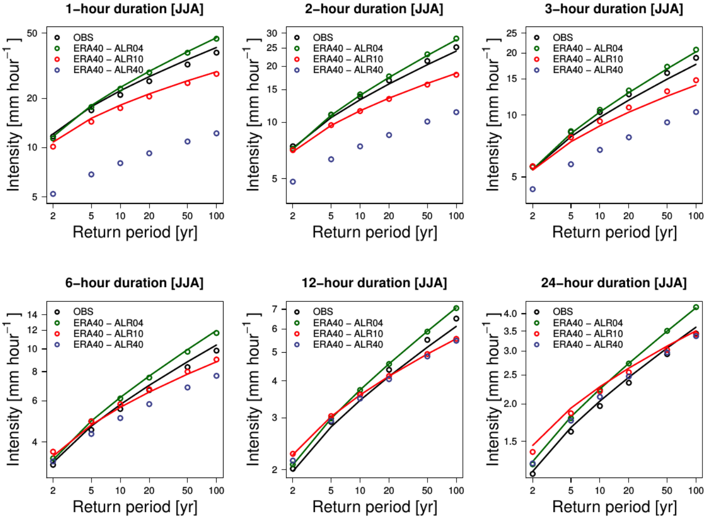
# Subdaily precipitation




OBS: "centennial" 10-minute precipitation observation series in Uccle

# References

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3. Giot, O., *et al.*: *Validation of the ALARO-0 model within the EURO-CORDEX framework*, Geosci. Model Dev., 9, 1143-1152, doi:10.5194/gmd-9-1143-2016, 2016.
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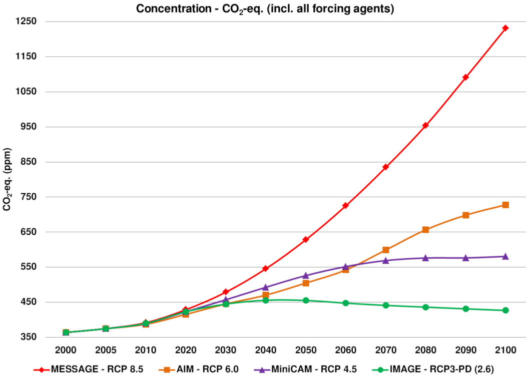
# Backup slides

# Climate scenarios




($CO_2$-equivalent vs time)

- Finished: RCP 8.5 2040-2100
- Ongoing: RCP 4.5 2040-2100
- Ongoing: RCP 2.6 2040-2100
- Planned: ∗ 2005-2040

# Relative change in yearly precipitation: RCP 8.5 (2070-2100) vs hist (1976-2005)